

## 700 MATERIAL DETAILS

Materials shall conform to the stated requirements and/or the requirements of the referenced specifications including modifications as noted.

*Copies of all Supplemental Specifications referenced in this section are on file with the City of Columbus Transportation Division.*

### 706 - CONCRETE AND CLAY PIPE

**706.000 General.** All rigid pipe produced under this section shall conform to the current applicable ASTM standards and the specific provisions set forth hereafter.

All pipe, both storm and sanitary, will be stamped noting it has been inspected and approved by City of Columbus personnel. Pipe without proper approval identification will not be permitted for installation. All design tables in ASTM C14, C76, C507, and current ODOT 706.02 and 706.04 are accepted designs with noted 0.01 inch (0.3 mm) crack and ultimate D loads. Modified and special designs will be evaluated by procedures set forth in either ASTM C76, C655, or C507.

The interior of all pipe shall conform to the internal size specified, and all pipe shall be free from fins, bulges, ridges, offsets, projections, defects, or roughness of any kind. Any such defects or irregularities shall be corrected as directed. The Inspector shall have the right to reject defective pipe and such rejected pipe shall not be shipped to the project. If rejected at the project, it shall be removed from the project and disposed of at the contractor's expense. Replacement pipe must be acceptable to the Inspector, and furnished at the contractor's expense.

Special fittings such as tees, wyes, radius, bends and transition pieces, shall conform to approved shop drawings and shall in all respects meet the requirements of these specifications for the type of pipe used. The ends (tongues, grooves, bells, and spigots) of all pipe shall not be treated, painted, or covered with any application of asphalt, tar, aluminum, cement, or other type paint unless approved by the Engineer.

All manufacturers of sewer pipe must have the necessary equipment and personnel required to perform all tests on the type and size of pipe they propose to furnish under these specifications.

***Lift Holes.*** *Not more than two holes may be cast, drilled, or otherwise neatly made in the shell of each piece of pipe for the purpose of handling or laying. The holes shall be tapered unless drilled, and before backfilling the tapered holes shall be filled with Portland cement mortar, or with precast concrete plugs which shall be secured with Portland cement mortar. Drilled holes shall be filled with Portland cement mortar. No lift holes are permitted in the concrete pipe designated for sanitary sewers.*

**CONCRETE PIPE 6 INCH (152 mm) TO 27 INCH (686 mm) SHALL NOT BE MOVED FROM THE CASTING YARD BEFORE SUCH PIPE HAS AGED A MINIMUM OF SEVEN DAYS AND MEETING THE 0.01 INCH (0.3 mm) CRACK TEST OR MAY BE MOVED AFTER 48 HOURS UPON MEETING 115 PERCENT OF THE 0.01 INCH (0.3 mm) CRACK TEST.**

**CONCRETE PIPE 30 INCH (762 mm) AND LARGER SHALL NOT BE MOVED FROM THE CASTING YARD BEFORE SUCH PIPE HAS AGED A MINIMUM OF FOURTEEN DAYS AND MEETING THE 0.01 INCH (0.3 mm) CRACK TEST OR MAY BE MOVED AFTER THE PIPE HAS AGED FOUR DAYS AND MEETS BOTH THE 0.01 INCH (0.3 mm) CRACK TEST AND MEETS THE MINIMUM CONCRETE STRENGTH REQUIREMENT AS VERIFIED BY CORE TESTING. PIPE MAY BE TESTED TO 115 PERCENT IN LIEU OF CORE TESTING.**

All concrete radius pipe shall be of the size, type, and minimum strength classification shown or specified in the contract documents. If required, the contractor shall submit to the Engineer detailed layout drawings of the pipe to be used to construct the curved portion of the sewer line. The maximum deflection angle turned at either end of any pipe section shall be 5° F.

Except for fittings and closure pieces the minimum net laying length of concrete storm and sanitary sewer pipe shall be as listed below:

<u><b>Storm Sewers</b></u>	<u><b>Minimum</b></u>
6" thru 18" (152-457 mm).....	4 feet (1.2 m)
21" thru 120" (5333048 mm) .....	6 feet (1.8 m)
126" and larger (3200 mm) .....	5 feet (1.5 m)
Elliptical Pipe .....	6 feet (1.8 m)

<u><b>Sanitary Sewers</b></u>	<u><b>Minimum</b></u>
6" thru 18" (152467 mm) .....	4 feet (1.2 m)
21" thru 120" (5333048 mm) .....	8 feet (1.8 m)
126" and larger (3200 mm) .....	5 feet (1.5 m)
Elliptical Pipe .....	6 feet (1.8 m)

<u><b>Storm and Sanitary Sewers</b></u>	<u><b>Minimum</b></u>
Radius Pipe - Of such length that the shorter side is at least .....	2 feet (0.6 m)

All extra strength vitrified clay pipe shall meet the requirements of ASTM C700 and shall have the following minimum laying lengths:

<u><b>Size (Diameter)</b></u>	<u><b>Minimum Laying Length</b></u>
Pipe 4" thru 36" (102-914 mm) .....	3 feet (0.9 m)
Yard T Fittings 4" thru 12" (102-305 mm) .....	2 feet (0.6 m)
15" thru 36" (381-914 mm) .....	3 feet (0.9 m)

Closure and Repair Pieces ..... As required

Blisters shall not exceed 1 inch (25 mm) in diameter and project no more than 1/16 inch (1.6 mm) above the surrounding surface of the pipe.

**706.001 Test Requirements.** After design approval, all pipe shall be tested in accordance with the provisions set forth in this section, and all applicable ASTM standards.

**Physical Test.**

1. **Three-Edge Bearing.** At least one full length section of each size, class, and wall thickness for each 200 consecutive pieces of continuous production run for sanitary pipe and 400 pieces for storm sewer pipes.
2. **Concrete Cylinders.** Three cylinders will be cast for each days production for each size, class, and wall thickness. Cylinders will be broken at 28 days unless producer requests earlier time. Acceptance will be based on ACI301 criteria. On dry cast pipe, cylinders may be waived in lieu of core samples.
3. **Core Samples.** Extracted for concrete strength verification at discretion of City inspection personnel. Acceptance will be based on ACI301 criteria.
4. **Vacuum Test.** (Sanitary only) on each individual piece on sizes 6 sizes (152 mm) thru 36 inches (914 mm). Sizes above 36 inches (914 mm) will be subject to absorption and permeability tests.
5. **Absorption Test.** (Sanitary only) minimum 1 test per size and class per project.
6. **Hydrostatic Test.** At discretion of City inspection personnel per ASTM C497. *Minimum one per size per year.*
7. **Permeability Test.** *At discretion of City inspection personnel per ASTM C492. Minimum one per size per year.*

**706.002 Patching, Repair, and Fabricated Specials.** Procedures and materials for patching and repair of pipe must be reviewed and approved by City inspection personnel. Concrete patching material must meet or exceed the required strength of the pipe. Fabricated specials shall be cured at the casting yard for a minimum of 48 hours prior to shipment.

**706.003 Curing.** All products manufactured under this section shall be protected and cured in accordance with the American Concrete Pipe Handbook, the Clay Pipe Engineering Manual, American Concrete Institute, and general practices acceptable to the industry.

**706.01 NonReinforced Concrete Pipe.** Shall conform to ASTM C14 and requirement set forth herein.

**706.02 Reinforced Concrete Pipe.** Shall conform to ASTM C76 and requirement set forth herein.

**706.04 Reinforced Concrete Elliptical Culvert, Storm Drain and Sewer Pipe.** Shall conform to ASTM C507 and requirement set forth herein.

**706.05 Precast Reinforced Concrete Box Sections.** *ASTM C 1433 with the following exceptions and additions. Ensure that the manufactures have been pre-approved by the City of Columbus.*

6.1 Cement. Cement shall be Portland cement conforming to 701, except 701.07 is not permitted.

6.2 Aggregates. Aggregates shall meet the quality requirements of 703.02.

6.4 Steel Reinforcement. Steel shall be 709.10 or 709.12. Longitudinal distribution reinforcement for box sections with less than 2 feet (0.6 m) of cover and subjected to highway loadings may be 709.01 conforming to ASTM A 615, grade 60.

7.1 Design Tables. Only designs from Table 2 of the appropriate ASTM specifications are permitted. The box sizes (span x rise, in feet (meters)) shall be 3 x 3 (0.9 x 0.9); 6 x 4 (1.8 x1.2); 5 (1.5) 6 (1.8); 8 x 4 (1.5x1.8), 5 (1.5), 6 (1.8), 7 (2.1), 8 (2.4); 10 x 5 (3.0 x1.5), 6 (1.8), 7 (2.1), 8 (2.4), 9 (2.75), 10 (13.0); 12 x 4 (3.6x1.2), 6 (1.8), 8 (2.4), 10 (3.0), 12 (3.6).

9.1 Mixture. The fresh concrete shall contain  $6 \pm 2$  percent entrained air for wet cast box sections. The hardened concrete shall contain a minimum of 4 percent entrained air for all production types.

9.4 Handling. Lift holes shall not be permitted. Handling devices which do not require a hole through the box shall be used.

11.5 Position of Reinforcement. A minimum cover of 1/2 inch (12.7 mm) over both circumferential and longitudinal reinforcement shall be required at the mating surfaces of joints.

13. Inspection. Inspection shall be done at the manufacturing plant, or at other locations designated by the Engineer.

15. Marking. In addition to the required "COC approved" stamp, the identification of the plant shall be marked on each box section. *For box sections 14 feet (4200 mm) or greater, the reinforcing steel areas for the section shall be marked on*

*each box section. The manufacturer's name and required product information shall be placed on the inside of the box section within the top one half of the culvert.*

**706.051 Precast Reinforced Concrete ThreeSided Flat Topped Culverts.**

*Precast reinforced concrete three sided flat topped culverts shall be manufactured to comply with the following requirements. These culverts shall be flat deck structures with a minimum clear span (measured normal to the structure at the bottom of the haunch) of 14 feet (4.2 m) and a minimum opening rise (measured from bottom of leg to bottom of deck at the centerline of the structure) of 4 feet (1.2 m); and a maximum clear span of 34 feet (10.2 m) and maximum opening rising of 10 feet (3.0 m). Minimum wall and deck thicknesses shall be 10 inches (2.5 m) and 12 inches (3.0 m) respectively, measured under the haunch normal to the structure and at the centerline of the span measured perpendicular to the structure.*

**External Dimensions.** *To maintain constant wingwall, headwall, pavement buildup, and guardrail elevations the design in the plan reflects the external top slab elevation of the structure. This fixes the top of the slab elevation. If the structure supplied has a deck thicker than the plan design, the difference between the design top slab elevation and the supplied top slab elevation shall be accomplished by a reduction in leg length. Alternate methods to provide the difference between the design top slab elevation and the supplied top slab elevation may be approved by the City. No approval will be given to change the top slab elevation from that shown in the plans.*

*The clear span shown is the minimum for the structure. The clear span provided by the manufacturer may be greater than that shown. The exact footer locations both to elevation and offset shall be determined based on the manufacturer's shop drawings. These footer locations will be such that the centerline of the leg at the bottom of the haunch matches the centerline of the footer.*

*All changes to the project resulting from the manufacturer's dimensional changes in the structure shall be at no additional cost to the City.*

*These culverts are intended to be used for the conveyance of storm water, and will be subjected to earth and highway loadings. The culverts are designated by clear span, opening rise and length. The requirements of the 603 conduit shall apply except as modified hereafter.*

**Design.** *The culvert design shall be in accordance with the latest edition of the AASHTO Standard Specifications for Highway Bridges. The culvert dimensions shall be as shown, subject to the permissible variations contained hereinafter.*

**Modified and Special Designs.** *The manufacturer may request approval from the City for modified designs or special designs after the bid.*

**Reinforcing Development, Splices and Spacing.** *Exterior corner reinforcement shall be fully developed at the point of peak stress or it shall be lapped by a bent corner*

*bar. The bent corner bar shall extend past the point of peak stress 12 inches (300 mm) as a minimum or its development length modified by a factor to account for the area of steel required to area of steel provided and a factor to account for the percent of development remaining for the bar which it is lapping. The development length for welded wire fabric (709.10 or 709.12) or reinforcing steel (709.01) shall conform to AASHTO Standard Specifications for Highway Bridges.*

*Splices in circumferential (main) reinforcement shall be made by lapping and not by welding. Lap lengths shall be as per AASHTO Standard Specifications for Highway Bridges.*

*Spacing center to center of the circumferential (main) wires in a fabric sheet shall not be less than 2 inches (50 mm) nor more than 4 inches (100 mm). The spacing center to center of the longitudinal wires or bars shall not be more than 8 inches (200 mm).*

*All reinforcement design changes from the approved shop drawings shall be submitted to the City for approval.*

***Shop Drawing Requirements.*** *The manufacturer shall submit shop drawings for review and approval prior to manufacture. The shop drawings shall include the following:*

- 1. All structural design and loading information*
- 2. All material specifications*
- 3. All plan views*
- 4. All elevation views*
- 5. All headwall and wingwall attachment requirements*
- 6. All dimensions*
- 7. All maintenance of traffic phases*
- 8. All section sizes*
- 9. All design handling strengths*

*The structural design calculations shall be submitted with the shop drawings for approval by all preapproved manufacturers. Manufacturing shall not begin until written approval of the submitted shop drawings and design calculations has been received. The shop drawings shall also include the following special information as required:*

- 1. For top mounted guardrail, the guardrail plate and bolt locations will be shown in the plan view. Holes shall be a minimum of 6 inches (150 mm) from a joint.*
- 2. For side mounted guardrail, additional reinforcing details shall be shown as per the plan details.*

*Where circumferential (main) reinforcement is composed of bars, crack control criteria shall be checked. Calculations performed by a registered professional engineer*

verifying that the proposed bar spacing meets the crack control criteria shall be submitted with the shop drawings. [  $Z = 150$  inside face (interior surface) and  $Z = 130$  outside face (exterior surface)].

**Materials.** All materials shall be tested and approved prior to inclusion into the culvert sections. Any piece made with untested or unapproved material will be subject to rejection.

**Cement.** Portland cement shall conform to 701.01, 701.02, 701.04 or 701.05.

**Aggregates.** Fine aggregates shall be a sand conforming to 703.02. Coarse aggregate shall have a standard size designation from a number 5 to a number 8 inclusive as specified in 703.01 and the quality requirements of 703.02 shall apply.

**Admixtures.** Air entraining admixtures conforming to 705.10 and chemical admixtures conforming to 705.12 approved Types A, B, D or F may be used. The addition of calcium chloride to the mix is not permitted.

**Steel Reinforcement.** Reinforcement shall consist of welded wire fabric conforming to 709.10 or 709.12, or deformed billet steel bars conforming to CMS 709.01, Grade 60. All reinforcement shall be epoxy coated as per 709.00 or 709.14. In lieu of epoxy coated reinforcement, a corrosion inhibiting concrete admixture may be used, if approved by the owner. Reinforcement which projects from the precast structure into a castinplace structure which does not contain a corrosion inhibitor admixture shall be epoxy coated in compliance with 709.00 or 709.14.

Manufacturers should recognize that the corrosion inhibitors and admixtures may have an effect on strength, entrained air content, workability, etc. of their concrete mixes. The manufacturer's choice of one of these corrosion inhibitors does not alleviate meeting all design requirements of this structure.

**Joints.** The precast reinforced concrete flat topped threesided culvert sections shall be produced with a keyway joint in the top slab. The keyway shall provide a void volume equivalent to that of 12 inches (300 mm) prestressed beam as per Standard Construction Drawing PSBD193. The joint in the leg sections shall be of such design as to produce a shear key or interlocking joint. Nonadjoining outside legs shall be flat. The joint surfaces shall be sandblasted to the satisfaction of the City, or a 2000 psi (14 Mpa) water blast no more than 14 days prior to shipping. The culvert shall be of such design that the sections when laid together will make a continuous line with a smooth interior free of appreciable irregularities, all compatible with the permissible variations hereinafter.

Mortar for the keyway joints shall be a nonshrinking nonmetallic mortar meeting the requirements of 705.22. The mortar shall be prepared, placed and cured in accordance with the manufacturer's recommendations. Before mortaring the keyway joint

*shall be thoroughly cleaned of all dirt, dust and other foreign matter. The keyway joint surfaces shall be wetted, but no free water shall be allowed to remain in the keyway joint.*

*The joint exterior beyond the limits of membrane waterproofing shall be covered with a minimum of a 12 inches (300 mm) wide wrap centered on the joint. The external wrap shall be an approved type. Care shall be exercised to keep the joint wrap in its proper location during backfilling.*

***Manufacture Mixture.*** *Aggregate, cement, water shall be manufactured as per 499.04, 499.05, 499.06 to produce a homogeneous concrete, meeting the strength requirements as stated. The temperature requirements of 511.06 and 511.12 shall be met. In no case, however, shall the proportion of Portland cement be less than 564 pounds per cubic yard (335 kg/m<sup>3</sup>) of concrete. The hardened concrete shall contain a minimum of 4 percent entrained air. The w/c ratio shall not exceed 0.53. If a corrosion inhibiting admixture is used, it shall be added as an aqueous solution. The water in such solution shall be counted as mixing water for the purpose of determining the water to cement ratio of the concrete.*

***Construction Placement of Reinforcement.*** *The concrete cover dimension over reinforcement shall be a minimum of 2 inches (50 mm) in the slab and in the exterior of the leg. The interior of the leg reinforcement cover shall taper from 1 inch (25 mm) at the bottom of the leg to 2 inches (50 mm) at the bottom of the haunch. The clear distance of the circumferential (main) reinforcement at the ends shall not be less than 5/8 inch (16 mm) nor more than 2 inches (50 mm) from the ends of the culvert. Reinforcement shall be assembled utilizing any combination of single or multiple layers (3 maximum) of welded wire fabric or steel bars. The welded wire fabric shall be composed of circumferential (main) and longitudinal wires meeting the spacing requirements hereinafter. The ends of the longitudinal reinforcement shall not be more than 2 inches (50 mm) from the ends of the culvert. Then ends of longitudinal reinforcement shall have a minimum cover of 1/2 inch (13 mm), and spacers used to position the reinforcement shall be plastic or epoxy coated steel regardless of whether a corrosion inhibiting admixture is used.*

***Forms.*** *The forms used shall be sufficiently rigid to maintain the culvert dimensions within the permissible variations given. All the casting surfaces shall be of a smooth material. All forms shall be in place until the design handling strength as defined in the shop drawing is met. A cylinder will be tested to check each section's design handling strength. This test may be repeated as often as needed. The City may waive the right to witness this test. The time of the test will be forwarded to the City at the time of that sections' pour. Only one cylinder passing will ensure that the design handling strength has been met. If the shop drawing shows no design handling strengths, then the minimum handling strength shall be assumed to be 100 percent of the design strength.*

***Curing.*** *The culvert shall be cured in the forms for the length of time required to obtain the specified minimum design handling strength. The curing shall then continue until the specified minimum design strength is met. Any one of the following methods of curing or combinations thereof shall be used for culvert sections:*

**Water Curing.** The culvert sections may be water cured in accordance with 511.12 and 511.14 Method (a) until the required minimum design compressive strength is met.

**Membrane Curing.** The culvert sections may be membrane cured in accordance with 511.13 Method (b) until the required minimum design compressive strength is met.

**Accelerated Curing.** The concrete shall be given an accelerated cure by low pressure steam or radiant heat within a suitable insulated enclosure to contain the live steam or heat. The initial application of the steam or heat shall be from two to four hours after the final placement of concrete to allow the initial set to take place. If retarders are used, the waiting period shall be increased to four to six hours. As an alternative, the actual time of initial set may be determined in accordance with ASTM C 403. Curing cannot be started until the actual time to initial set has elapsed.

During the waiting period the temperature within the curing enclosure shall not be less than 50° F (10° C).

During the initial application of live steam or radiant heat, the ambient temperature within the curing enclosure shall increase at an average rate not exceeding 40° F (22° C) per hour until the curing temperature is reached.

The maximum curing temperature shall not exceed 150° F (65° C). The design temperature shall be held until the concrete has reached the desired design strength. Application of live steam shall not be directed on the concrete forms so as to cause localized high temperatures.

**Handling and Transportation.** Holes for handling or setting are not permitted. No members shall be moved before the design handling strength of the concrete is reached, or shipped before the design strength of the concrete is reached. Manufacturers shall have equipment necessary to handle and transport the pieces without damaging them.

**Physical Requirements.** The minimum design concrete compressive strength shall be 5000 psi (35 Mpa) at 28 days. All designs greater than 5000 psi (35 Mpa) shall submit with the shop drawing a mix design and a history of the mix design.

**Testing Compressive Strength Cylinders.** Concrete compressive strength shall be determined using 6 inch by 12 inch (150 mm x 300 mm) cylinders. For each section of the culvert at least four cylinders shall be produced and marked so that they are identifiable with the matching culvert section. The cylinders and matching culvert section shall be kept together to guarantee the cylinders are matched with the corresponding culvert section; or, upon agreement by the City, the cylinders may be kept at a location that will provide the same environment as the culvert sections. Acceptance of strength will be based on ACI301, 17.2

*At the manufacturer's request two cylinders shall be tested for each section of the structure at the time the manufacturer feels the required strength has been met. If these cylinders fail, 48 hours of additional curing for that section shall take place before additional cylinders are tested. The 48 hours may be waived by the City. If 28 days pass with no cylinders or cores passing for a section of the structure, then that section is rejected.*

*The City shall have the option of using only cores for acceptance of each section or having a sections' cores represent each group of 15 pieces. A maximum of 4 cores per section will be taken.*

***Compressive Strength Cores.*** *Concrete compressive strength shall be determined from compression tests made on cores. The cores shall be obtained and tested for compressive strength in accordance with the provisions of ASTM C 497 Section 6 with the following exception to Section 6.4.2. The cores shall be treated the same as the piece it represents. Two cores shall be cut from each section per test.*

*The compressive strength of the cores tested shall meet the same requirements as the compressive strength cylinders.*

***Plugging Core Holes.*** *The core holes shall be plugged by the manufacturer in a manner such that the culvert section will meet all of the test requirements of this specification. The core holes shall be plugged by using a concrete that is the same as that used in the section, or by a nonshrink grout that exceeds the concrete design strength and it is to be cured by one of the before mentioned methods.*

***Coring Equipment.*** *Every manufacturer furnishing structure sections under this specification shall furnish equipment and personnel necessary to obtain the cores. The core diameter shall be as required by the City.*

***Air Determination.*** *Two cores shall be taken from each days production for the determination of air content. The City may exercise the option of accepting the results of air test performed in accordance with ASTM C 231 by a certified concrete technician.*

***Permissible Variation Internal Dimensions.*** *The internal dimensions (span and rise) shall not vary more than 2 inches (50 mm) from the shop drawings. The haunch dimensions shall not vary more than 3/4 inch (19 mm) from the dimensions shown on the shop drawings.*

*The deck and walls shall be perpendicular with a diagonal difference of not more than 0.5 percent.*

***Deck and Wall Thickness.*** *The deck and wall thickness shall not be less than that shown on the shop drawings by more than 1/2 inch (13 mm). A thickness more than that required shall not be cause for rejection.*

**Length of Opposite Surfaces.** Variations in laying lengths of 2 opposite surfaces of the culvert sections shall not be more than 1 inch (25 mm), except where beveled ends for laying of curves are specified.

**Length of Section.** The length of each section shall be within 1/2 inch (13 mm) measured at both sides and middle, then averaged.

**Position of Reinforcement.** The maximum variation in the position of the reinforcement shall be 3/8 inch (9 mm), except the cover over the reinforcement for the external surface of the top slab shall not be less than 2 inches (50 mm). The above tolerances or cover requirements do not apply to mating surfaces at the joint.

**Area of Reinforcement.** The areas of steel reinforcement shall be the design steel areas per linear foot (per meter). Steel areas greater than those required shall not be cause for rejection. The permissible variation in diameter of any reinforcement shall be as prescribed in the ASTM specification for that type of reinforcement. Any change in reinforcement from the shop drawing shall be resubmitted for approval.

**Workmanship and Finish.** The culverts shall be free of fractures spalls and chips. All surfaces shall have a smooth and regular finish being defined as a 1/4 inch within 4 feet (6 mm within 1.2 m). The ends shall be normal to the walls and centerline within the limits of variations given, except where beveled ends are specified. Form seams and slight surface irregularities that would be expected from a wood panel forming system will not be cause for rejection. Hairline cracks less than .01 in. (.25 mm) will not be cause for rejection.

Culverts may be repaired, if necessary, because of occasional imperfections due to manufacturing, handling damage, or construction, which are determined, by the City, not to be detrimental to the function of the section. Repairs shall be made in accordance with the City's requirements. No additional payment will be made for culvert repairs. Repairs will be acceptable if, in the opinion of the City, the repairs are sound, properly finished and cured.

Culverts shall be subject to rejection for failure to conform to any of the requirements contained hereinabove or any of the following:

1. Fractures or cracks passing through the slab or wall.
2. Defects that indicate imperfect proportioning, mixing, forming, and consolidation.
3. Honeycombed or open texture.
4. Precast damaged ends, where such damage would prevent making a satisfactory joint.

5. *Not marking the product the day the forms are removed.*

**Inspection.** *The quality of materials, the process of manufacture, and the finished culvert shall be subject to inspection by the City.*

*The inspection shall be done at the time of production unless otherwise directed by the City.*

**Basis of Acceptance.** *Acceptability of the threesided culvert shall be determined by the results of the concrete compressive strength tests, (cylinder or cores), fresh air test, visual observations, and dimensional verification. The manufacturer shall also submit shop drawings and design calculations for review and approval.*

*A notice of production and a production schedule will be submitted to the City two weeks prior to production. No culvert sections shall be shipped until they are approved by the City. All membrane waterproofing shall be applied after the structure sections have been set.*

**Marking.** *The following information shall be clearly marked on the interior of the culvert 1 foot (300 mm) below the leg haunch by waterproof paint:*

***Culvert span and rise***

***Design earth cover***

***Date of manufacture***

***Name or trademark of the manufacturer***

*This information shall be added upon removal of the forms.*

*The manufacturer may be required to repeat the above markings before the project is final.*

*Prior to shipment, a COC approved stamp must be placed on each piece.*

**706.052 Precast Reinforced Concrete Arch Sections.** *This item shall consist of manufacturing precast reinforced concrete arch sections for culverts. Precast arch sections shall be manufactured in accordance with these specifications and shall be designated by span, rise and cover; the cover shall be 1.0 feet (300 mm) minimum above the exterior crown section. The arch sections are designed in accordance with the AASHTO Standard Specifications for Highway Bridges and the Ohio "Supplement" to these specifications.*

**DESIGN LOAD:** *HS2044 (MS18) and the Alternate Military Loading.*

**DESIGN STRESSES:** *499 Concrete compressive strength 4000 psi (28MPa) for spans under 32 feet. 5000 psi for spans greater than 32 feet.*

*Reinforcing Steel - 709.01 or 709.03, Grade 60 (Grade 420).*

*Welded Wire Fabric - 709.10 or 709.12.*

*Dimensions shall be as prescribed in the plans.*

***Materials – Concrete.*** *The concrete for the arch sections shall meet the requirements of 499; be air entrained such as to meet the hardened concrete air requirements; and composed of portland cement, fine and coarse aggregates, admixtures and water. Portland cement shall conform to the requirements of 701.04 or 701.05. Aggregates shall meet the quality requirements of 703.02. The air entraining admixture shall conform to 705.10. The hardened concrete shall contain a minimum of 4 percent air. The addition to the mix of calcium chloride will not be permitted.*

***Materials - Reinforcing And Hardware.*** *All reinforcing steel for the sections shall be fabricated and placed in accordance with the plans and these specifications. Reinforcement shall consist of welded wire fabric (709.10 or 709.12), or deformed billet-steel bars [707.01 or 709.03, Grade 60 (Grade 420)].*

***Shop Drawing Requirements.*** *The manufacturer shall submit shop drawings for review and approval prior to manufacture. The shop drawings shall include the following:*

- 1. All structural design and loading information*
- 2. All material specifications*
- 3. All plan views*
- 4. All elevation views*
- 5. All headwall and wingwall attachment requirements*
- 6. All dimensions*
- 7. All maintenance of traffic phases*
- 8. All section sizes*

*The structural design calculations shall be submitted with the shop drawings for approval by all pre-approved manufacturers. Manufacturing shall not begin until written approval of the submitted shop drawings and design calculations has been received. Four weeks should be allowed for approval.*

*The shop drawings shall also include the following special information as required:*

- 1. For top mounted guardrail, the guardrail plate and bolt locations will be shown in the plan view. Holes shall be a minimum of 6 inches (150 mm) from a joint.*
- 2. For side mounted guardrail, additional reinforcing details shall be shown as per the plan details.*

**Manufacture.** *The aggregates, cement and water shall be proportioned and mixed in a batch mixer to produce a homogeneous concrete meeting the strength requirements of these specifications. The proportion of portland cement in the mixture shall not be less than 564 pounds per cubic yard (335kg/m<sup>3</sup>) of concrete.*

*The arch sections shall be cured for a sufficient length of time so that the concrete will develop the specified compressive strength in 28 days or less. Any one of the methods of curing or combination thereof shall be used.*

**Steam Curing.** *The sections may be low pressure, steam cured by a system that will maintain a moist atmosphere.*

**Water Curing.** *The sections may be water cured by any method that will keep the sections moist.*

*The forms used in manufacture shall be sufficiently rigid and accurate to maintain the sections dimensions within the permissible variations given in these notes. All casting surfaces shall be of smooth material.*

*Holes for handling or setting in the top will not be permitted unless a method for handling, repairing and sealing of the holes is submitted with shop drawings and is approved. A maximum of two holes may be cast into each leg as needed for handling as per approved shop drawings.*

*The sections shall be stored in such a manner to prevent cracking or damage. The units shall not be stored in an upright position until the compressive strength is a minimum of 4,000 psi (28 MPa).*

*The cover of concrete over the outside circumferential reinforcement shall be 2 inches (50 mm) minimum. The cover of concrete over the inside circumferential reinforcement shall be 1 1/2 inches (38 mm) minimum. The clear distance of the end circumferential wires shall not be less than 1 inch (25 mm) nor more than 2 inches (50 mm) from the ends of the sections. Reinforcement shall be assembled utilizing single or multiple layers of welded wire fabric (3 layer maximum), or utilizing a single layer of deformed billet-steel bars. The welded wire fabric shall be composed of circumferential and longitudinal wires meeting the spacing requirements of these specifications and shall contain sufficient longitudinal wires extending through the section to maintain the shape and position of reinforcement. Longitudinal distribution reinforcement may be welded wire fabric or deformed billet-steel bars and shall meet the spacing requirements of these specifications. The ends of the longitudinal distribution reinforcement shall be not more than 3 inches (75 mm) from the ends of the sections.*

*The outside and inside circumferential reinforcing steel for the corners of the culvert shall be bent to such an angle that it is approximately equal to the configuration of the culverts outside corner.*

*Tension splices in the circumferential reinforcement shall not be made. For splices other than tension splices, the overlap shall be a minimum of 12 inches (300 mm) for welded wire fabric or deformed billet steel bars. The spacing center to center of the circumferential wires in a wire fabric sheet shall be not less than 2 inches (50 mm) nor more than 4 inches (100 mm). For the wire fabric, the spacing center to center of the longitudinal wire shall not be more than 8 inches (200 mm). The spacing center to center of the longitudinal distribution steel for either line of reinforcing in the top slab shall be not more than 16 inches (410 mm).*

*The sections shall be produced with butt ends. The ends of the sections shall be such that when the sections are laid together they will make a continuous line of sections with a smooth interior free of appreciable irregularities, all compatible with the permissible variations in these specifications. A chamfer shall be provided on the outside surface at the sections joint to form a void for a 7/8 inch (24 mm) by 13/8 inch (34 mm) Flexible Plastic Gasket 706.14. The chamfered portion of the joint shall be primed at the project site. The joints shall be clean and free of all debris before the primer is applied. The primer supplied shall be as per the manufacturer's recommendations. The flexible plastic gasket shall be placed continuous from the bottom of the leg on 1 side to the bottom of the leg on the other side. The outside of each joint shall then be covered with a 9 inch (225 mm) wide strip of Type 3 membrane waterproofing 711.29 centered. The Type 3 membrane waterproofing shall be installed as per the manufacturer's recommendations.*

*The sections shall be substantially free of fractures. The ends of the sections shall be normal to the walls and center line of the section, within the limits of variations given in these specifications except where beveled ends are specified. The surface of the section shall be a smooth steel form or trowelled surface. Trapped air pockets causing surface defects shall be considered as part of a smooth steel form finish.*

*Sections may be repaired, if necessary, because of imperfections in manufacture or handling damage and will be acceptable if in the opinion of the City, the repairs are sound, properly finished and cured, and the repaired section conforms to the requirements of these specifications.*

*The quality of materials, the process of manufacture, and the finished sections shall be subject to inspection by the City.*

*Sections shall be subject to rejection on account of any of the requirements in these specifications. Individual sections may be rejected because of any of the following:*

- 1. Fractures or cracks passing through the wall, except for a single crack that does not exceed one half the thickness of the wall.*
- 2. Defects that indicate proportioning, mixing, molding, and consolidation not in compliance with these specifications.*

3. *Honeycombed or open texture.*
4. *Damaged ends where such damage would prevent making a satisfactory joint.*
5. *Not marking the product the day the forms are removed.*

*Each section shall be clearly marked by waterproof paint. The following information shall be shown on the inside surface of the vertical leg of the section:*

***Section Span x Rise***

***Earth Cover***

***Date of Manufacture***

***Name or Trademark of the Manufacturer***

***Permissible Variations.*** *The internal dimensions shall vary not more than 1 percent from the design dimensions nor more than 1 1/2 inches (38 mm), whichever is less. The haunch dimensions shall vary not more than 3/4 inch (19 mm) from the design dimension.*

*The slab and wall thickness shall not be less than that shown in the design by more than 1/4 inch (6 mm). A thickness more than that required in the design shall not be cause for rejection.*

*Variations in laying lengths of 2 opposite surfaces shall not be more than 5/8 inch (15 mm) in any section, except where beveled ends for laying of curves are specified by the City.*

*The underrun in length of a section shall not be more than 1/2 inch (13 mm).*

*The maximum variation in position of the reinforcing shall be plus or minus 1/2 inch (13 mm). In no case shall the cover over the reinforcement be less than 1 1/2 inch (38 mm) from the outside circumferential steel or be less than 1 inch (25 mm) from the inside circumferential steel as measured to the external or internal concrete surface. These tolerances or cover requirements do not apply to mating surfaces of the joints.*

*The areas of steel reinforcement shall be the design steel areas as noted and approved in the shop drawing. Steel areas greater than those shown shall not be cause for rejection.*

***Testing Compressive Strength Cylinders.*** *Concrete compressive strength shall be determined using 6 inch by 12 inch (150 mm x 300 mm) cylinders. For each section of the culvert at least 4 cylinders shall be produced and marked so that they are identifiable with the matching culvert section. The cylinders and matching culvert section shall be kept together to guarantee the cylinders are matched with the corresponding culvert section; or, upon agreement by the City, the cylinders may be kept at a location that will*

*provide the same environment as the culvert sections. Each pair of cylinders shall have an average strength of not less than the design strength, and each cylinder shall not have less than 90 percent of the design strength. Any section whose cylinders do not pass shall be cored.*

*At the manufacturer's request 2 cylinders shall be tested for each section of the structure at the time the manufacturer feels the required strength has been met. If these cylinders fail, 48 hours of additional curing for that section shall take place before additional cylinders are tested. The 48 hours may be waived by the City. If 28 days pass with no cylinders or cores passing for a section of the structure, then that section is rejected.*

*The City shall have the option of using only cores for acceptance of each section or having a sections' cores represent each days production. A maximum of 4 cores per section will be taken.*

***Compressive Strength Cores.*** *Concrete compressive strength shall be determined for compression tests made on cores. The cores shall be obtained and tested for compressive strength in accordance with the provisions of ASTM C 497 Section 6 with the following exception to Section 6.4.2. The cores shall be treated the same as the piece it represents. Two cores shall be cut from each section per test.*

*The compressive strength of the cores tested shall meet the same requirement as the compressive strength cylinders.*

***Plugging Core Holes.*** *The core holes shall be plugged by the manufacturer in a manner such that the culvert section will meet all of the test requirements of this specification. The core holes shall be plugged by using a concrete that is the same as that used in the section, or by a nonshrink grout that exceeds the concrete design strength and it is to be cured by one of the before mentioned methods.*

***Coring Equipment.*** *Every manufacturer furnishing structure sections under this specification shall furnish equipment and personnel necessary to obtain the cores. The core diameter shall be as required by the City.*

***Hardened Air Determination.*** *If required by the City, two cores shall be taken from each days production for the determination of air content. The City may exercise the option of accepting the results of air test performed in accordance with ASTM C 231 by a certified concrete technician.*

***Inspection.*** *The quality of materials, the process of manufacture, and the finished culvert shall be subject to inspection by the City.*

*The inspection shall be done at the time of production unless otherwise directed by the City.*

**Basis of Acceptance.** Acceptability of the three sided culvert shall be determined by the results of the concrete compressive strength tests, (cylinder or cores), fresh air test, visual observations, and dimensional verification. The manufacturer shall also submit shop drawings and design calculations for review and approval

A notice of production and a production schedule will be submitted to the City two weeks prior to production. No culvert sections shall be shipped until they are approved and stamped by the City. All membrane waterproofing shall be applied after the structure sections have been set.

Prior to shipment, a COC approved stamp must be placed on each piece.

**706.08 Vitrified Clay Pipe.** ASTM C 700, with the following exceptions and additions:

1. **Test Methods.** All tests except hydrostatic shall be performed in accordance with ASTM C 4 and 301. The number of specimens for test shall be in accordance with Section 706.01.
2. **Inspection.** Inspection shall be done at both the project site and production facility. Random samples may be obtained from material delivered to the project site for compliance verification.

**706.10 Bituminous and Butyl Rubber Pipe Joint Materials.** Cold applied, mineral filled, joint sealing compound for joints of bell and spigot or tongue and groove sewer or drain pipe.

**Composition.** A steam-refined petroleum asphalt or a refined coal tar, dissolved in a suitable solvent, and containing an appropriate stiffener.

**General Requirement Bituminous.** The bituminous plastic cement shall be a smooth, uniform mixture, not thickened or livered, and it shall show no separation which cannot be easily overcome by stirring. The material shall be of such consistency and properties that it can be readily applied with a trowel, a putty knife, or with a caulking gun without pulling or drawing. The material, when applied to metal, concrete, or vitrified clay surfaces, shall exhibit good adhesive and cohesive properties and shall have only slight shrinkage after curing. The material shall not be damaged by exposure to below freezing temperatures.

**Detail Requirements.** Material shall conform to the following requirements:

1. When applied in layer 1/16 to 1/8 inch (1.6 to 3.2 mm) thick on a tinned metal panel and cured at room temperature for 24 hours, the bituminous plastic cement shall set to a tough, plastic coating, free from blisters.

	<u>Minimum</u>	<u>Maximum</u>
2. Grease cone penetration (unworked, 150 grams, 250 C, 5 Sec., ASTM D 217, mm/10) .....	175	250
3. Weight, pounds per gallon (K/L) .....	9.75 (1.17)	___
4. Nonvolatile, 10 grams, 105C110C, 24 hours, percent .....	75	___
5. Ash, by ignition, percent .....	25	45

**General Requirement - Butyl Rubber.** Preformed butyl rubber material may also be used. The butyl rubber shall be of sufficient quantity to seal the joint but not necessarily fill the joint when the pipe is placed in its final position. When butyl material is used, both side of the joint shall be primed with and asphalt based primer as recommended by the manufacturer. Material will meet AASHTO Specification M198B. Size of Sealant shall conform to Manufacturer's recommendations for a given pipe size.

**706.11 Resilient and Flexible Gasket Joints.** For concrete pipe, ASTM C 443. Unconfined gaskets meeting the requirements of ASTM C443 and C361 may be used if approved by the Engineer.

**706.12 Resilient and Flexible Joints.** For vitrified clay pipe, ASTM C 425.

**706.13 Precast Reinforced Concrete Manhole Riser Sections, Catch Basins, Inlet Tops, and Temporary Barrier.** All structures will conform to ASTM C478.

*Perform compression tests for satisfying the minimum specified concrete strength requirements from cores not less than 3 1/2 inches (90 mm) in diameter drilled from the wall of the risers, cones, tops, or barriers. Obtain cores prepared for testing, and tested by the appropriate methods of ASTM C 497 (ASTM C 497 M). In addition, ensure that all concrete compression tests made on cores are drilled from precast sections. Provide precast catch basins, inlet tops, and temporary barriers that have 6 ± 2 percent air in the hardened concrete.*

Absorption tests do not apply.

Wet Cast Items will require 6 ± 2% entrained air as tested per ASTM C138.

Dry Cast Items do not require entrained air.

**706.14 Flexible Plastic Gaskets.** For concrete pipe, AASHTO M 198, Type B, with the following exception:

4.3 Flash point and fire point are waived.

**706.15 Resilient Connectors Between Precast Manhole Riser Sections, Catch Basins, Inlets and Pipes.** Material and performance requirements shall meet the standards of ASTM C923, and be approved by the Engineer. The actual joint may be one of the following designs:

- (a) Rubber sleeve with stainless steel band.
- (b) Rubber gasket compression.
- (c) Rubber gasket expansion.